Farmers' valuation of incentives to produce genetically modified organism-free milk: Insights from a discrete choice experiment in Germany

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ABSTRACT

This paper investigates farmers' willingness to participate in a genetically modified organism (GMO)-free milk production scheme offered by some German dairy companies. The empirical analysis is based upon discrete choice experiments with 151 dairy farmers from 2 regions in Germany. A conditional logit estimation reveals a strong positive effect of the price premium on offer. Reliable feed monitoring and free technical support increase the likelihood of scheme adoption, the latter however only in farms that have been receiving technical support in other fields. By contrast, any interference with the entrepreneurial autonomy of farmers, through pre-arranged feed procurement or prescriptive advice on the part of the dairy company, lowers acceptance probabilities. Farmers' attitudes toward cultivation of genetically modified soy, their assessment of the market potential of GMO-free milk and future feed prices were found to be significant determinants of adoption, as are farmer age, educational status, and current feeding regimens. Respondents requested on average a mark-up of 0.80 eurocents per kilogram of milk to accept a contract. Comparison of the estimates for the 2 regions suggests that farmers in northern Germany are, on average, more likely to convert to genetically modified-free production; however, farmers in the south are, *ceteris paribus*, more responsive to an increase in the price premium offered. A latent class model reveals significant differences in the valuation of scheme attributes between 2 latent classes of adopters and nonadopters.

Key words: genetically modified organism-free milk production scheme, farmer valuation, discrete choice modelling, latent class analysis

INTRODUCTION

European consumers have been shown to be critical of new technologies such as the use of genetically modified feed or growth hormones in animal husbandry (Bredahl, 2001; Burton et al., 2001; Lusk et al., 2003). A comprehensive review of consumers' attitudes toward new food technologies revealed that perceived naturalness is highly valued. Moreover, the use of genetically modified organisms (GMO) in food production affects purchasing behavior more adversely than other novel food technologies such as nanotechnologies (Rollin et al., 2011). According to Costa-Font et al. (2008), citizens of Northern European countries and France are less tolerant to genetically modified (GM) food than citizens of the United States and southern European countries. In a study among French consumers ($n = 97$) on willingness to pay (WTP) for food products that differ in their content of GM ingredients, Nussair et al. (2004) found that 35% of respondents are generally unwilling to purchase such products and that a GM-free guarantee raises the WTP for biscuits by 8%. A cross-cultural comparison of consumers' WTP for rib-eye steak confirms that European consumers are more adverse toward the feeding of GM corn than US consumers. For example, the German respondents were willing to pay \$4.40 per pound more than US consumers for a steak produced without GM feed (Lusk et al., 2003). In general, European consumers are willing to accept increasing food bills to obtain products without GMO.

In response to these market developments, some retailers and processors have begun to impose GMO-free requirements on the primary stage of production. In Germany, the production of GM-free milk is one such example that has gained significant importance in recent years, in particular in Bavaria (Dorfner and Uhl, 2011). Some dairies, mostly located in the south of Germany, have included this value-added quality concept into their product portfolio. To increase transparency and aid consumers' purchasing decisions, a voluntary GM-free label based on the Law on the Execution of Genetic Engineering (EG-Gentechnik-Durchführungsgesetz)

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was introduced. Farmers who voluntarily accept the requirements for GM-free milk production must prove that they did not use feedstuffs listed as GM feed in EU Regulations 1829/2003 and 1830/2003. Dairy companies wishing to use the label have begun to develop GM-free production schemes in accordance with the law. These schemes offer a producer price increment to compensate farmers for the additional costs implied by the requirements. The increment varies between 0.5 and 2.0 eurocents per kilogram of raw milk (corresponding to an increase of 1 to 5% of the milk price) and depends mostly on the marketing success and type of products sold (Venus and Wesseler, 2012).

This paper aims to assess the willingness of dairy farmers to participate in a GM-free milk production scheme that a German dairy company is planning to launch. More specifically, we wish to clarify how the production requirements and the incentives offered by the scheme affect the willingness of farmers to participate and how much influence farm structure, farmer characteristics, attitudes, and region have on adoption behavior. The empirical analysis is based on discrete choice experiments (**DCE**) with 151 dairy farmers from 2 key milk production regions of Germany. Discrete choice experiments are mainly applied in fields such as marketing and environmental economics to analyze preferences of customers or citizens for certain attributes of consumer goods or environmental assets in hypothetical settings.

A brief overview of studies at the consumer level related to the acceptance of GMO in food (Burton et al., 2001; Lusk et al., 2003; Rigby and Burton, 2005) was given previously. The following review therefore focuses on relevant studies applying DCE at the producer level.

Birol et al. (2008) provided a comprehensive review of the application of DCE in Europe. The studies reviewed were designed to inform the implementation of policies relating to the environment and the agri-food sector. A large number of DCE have been conducted to investigate farmers' willingness to participate in agri-environmental schemes. Because such schemes are complex and adoption is influenced by many factors (Edwards-Jones, 2006), including characteristics of farm and farmers, the DCE method provides information on how schemes can be designed effectively. The valuation of scheme components is reflected by specific willingness-to-accept estimates that can be calculated by including payment as one of the attributes.

Espinosa-Goded et al. (2010) investigated the factors affecting farmer's willingness to participate in a proposed agri-environmental scheme paying Spanish farmers to cultivate alfalfa (a nitrogen-fixing crop). Farmer respondents were confronted with choice sets in which they had to choose among alternative contracts, each

involving distinct implementation requirements and a given compensation payment. The results indicate that free choice of the land offered for the program and unrestricted use of the alfalfa crop significantly increase respondents' willingness to sign a contract, as does previous experience with agri-environmental scheme participation. Acceptance is also influenced by regional conditions and by farmer and farm-specific characteristics. Significant differences were found in the ranking of attributes between different regions.

Jaeck and Lifran (2013) investigated the willingness of farmers to implement agro-ecological practices such as weed control and crop rotation in rice production. They applied a latent class model to account for heterogeneity in farm structures and farmer preferences. It was concluded that farmers' concern for environmental issues is a main driver for the implementation of environmentally friendly practices. Birol et al. (2006) used a DCE to investigate Hungarian farmers' preferences for traditional agricultural practices in home gardens, including crop variety diversity, maintaining landraces, integrated crop and livestock production, and organic cultivation. They found that the valuation of home garden attributes depends on household structure and regional conditions, such that in regions with a lack of food market access, poorer soils, and heterogeneous agro-ecological conditions, home gardens that are rich in crop variety diversity are highly valued. Socio-economic factors such as age and education were also found to affect preferences.

Studies investigating the acceptance of marketing schemes at the producer level are rare. Olynk et al. (2012) conducted a survey among Michigan dairy farmer to estimate the welfare losses when the option to use recombinant bovine somatotropin (**rbST**) is eliminated from the set of technologies. They designed choice scenarios with varying milk and corn prices, production practices (use of rbST or rbST-free), and different levels of milk production trends. They revealed that farmers, whether using rbST or not, had statistically significant welfare losses from the elimination of this technology. Whereas the Olynk et al. (2012) study dealt with a technology aimed at increasing productivity, the present study focuses on the acceptance of production methods to produce premium milk for a niche market.

Only a small number of studies have investigated the influence of farmers' attitudes toward GM technology in agriculture. Cook and Fairweather (2003), for instance, examined changes in intentions, attitudes, and beliefs of farmers regarding the use of GM technology and concluded that attitudes are a key factor for the decision-making process. In particular, producers' concerns about environmental risks, adverse effects on future generations, market acceptance, and commercial

viability were shown to influence their actions and decision-making related to the cultivation of GM crops. Breustedt et al. (2008) applied a DCE to explore the adoption behavior of German farmers concerning GM oilseed rape. Besides a strong effect of the gross margin difference between GM and non-GM varieties, they stressed the importance of farm and farmer characteristics for the likelihood of adoption. The attitudes of neighboring farmers toward GM crop cultivation were also found to have an important effect on the willingness of respondents to cultivate a GM variety. In a study on contract acceptance of farmers, Schulz (2013) investigated the willingness to fulfill additional contract requirements, including the avoidance of GM feed in dairy farming. The study revealed that the restriction of using only GM-free feed has a smaller negative effect on scheme adoption than the requirement to use only regionally grown feeds. Moreover, farmers who already use oilseed rape as protein component in their rations request less compensation to accept a contract requiring GM-free, regional feeding. The study corroborated the findings of Breustedt et al. (2008) that the attitude of farmers toward sustainability and the risks of GM crop cultivation had a significant effect on contract acceptance.

The present paper contributes to this strand of literature by applying a DCE to evaluate farmers' preferences for a GM-free milk production scheme and investigating the valuation of monetary incentives as well as technical support provided by dairy companies. In contrast to the studies cited in this section, we selected scheme attributes that are expected to have opposite effects: imposed contractual requirements that cause additional effort or disutility on the one hand, and technical support offered by dairy companies providing utility on the other.

MATERIALS AND METHODS

The Discrete Choice Experiment

Based on interviews with experts in dairy companies and the relevant literature, we identified factors that might either hinder or facilitate participation in GM-free production schemes. Based on this information we selected the following attributes for inclusion in the choice sets.

Feed Procurement

The effort and cost of switching the feeding regimen depends on the share and composition of concentrate feed in the ration (Dorfner and Uhl, 2011), more precisely, on the amount of GM feed to substitute (Venus

and Wesseler, 2012). Farmers can either use GM-free soy or switch their feeding regimens to other protein sources such as oilseed meal or grain legumes without suffering losses in yield performance or milk quality. The price of GM-free soy is around €40 to €80 per metric tonne above that of conventional (GM) soy (Dorfner and Uhl, 2011). Another important factor for adoption is the availability of GM-free soy on the European market. Soybeans for feed are imported to Germany mainly from the United States, Brazil, Argentina, and Paraguay, countries practicing large-scale GM soy cultivation. Feedstuffs free of GM are therefore scarce on the European market and thus more expensive (FEFAC, 2014). Against this background, we chose 3 alternative specifications for the attribute "feed procurement":

- farmer self-procurement (SELF_PROC),
- dairy company offers a list of regional suppliers of GM-free soy (LIST), and
- dairy company arranges the procurement of feedstuffs (DAIRY_PROC).

Monitoring

Feedstuffs labeled as GM free are credence goods in that the truth of the GM-free claim cannot be judged before purchase (Darby and Karni, 1973). Thus contract monitoring is needed to prove compliance with requirements. By including the attribute "monitoring" in the choice sets, we wished to establish which type of monitoring is preferred by farmers. We considered 3 different monitoring options:

- farmer self-documentation: the farmer documents all feedstuffs used with delivery notes and a supplier's declaration (DOCU),
- dairy company audits: the company carries out on-farm audits and carries out laboratory tests to substantiate the GM-free status of feed samples (DAIRY_CONT), and
- independent agency monitoring (Hein et al., 2014). The dairy company entrusts an independent agency with the task to ensure that no GM feed is used (EXT_AUD).

Technical Support

Interviews with dairy farmers revealed that a lack of knowledge of how to switch the feeding regimen or to avoid contamination with GMO is a potential obstacle to adoption. Thus, technical support in the form of advice offered to farmers could facilitate adoption. We considered 3 specifications of the attribute:

- free one-off advice offered by the dairy during conversion (DAIRY_ADV),
- free continuous advice by an advisory service (PLUS_ADV), and
- no advice offered (NO_ADV).

Price Premium

A premium on the producer price of raw milk (PRE-MIUM) is offered by the dairy company to compensate farmers for the extra cost involved in GM-free milk production. This payment is varied in the range of 0.5 to 1.0 to 1.5 to 2.0 eurocents per kilogram of milk as confirmed to be realistic (Venus and Wesseler, 2012).

The empirical analysis is based upon DCE with 151 dairy farmers in 2 German federal states, Bavaria (in the south) and Schleswig Holstein (in the north). These states represent the 2 main milk production regions of Germany. Bavaria represents upland and mountainous dairy farming systems with small farms; Schleswig-Holstein represents lowland dairy systems with larger farms and more favorable natural circumstances. The data were collected in 2013 using a paper-based questionnaire and stratified sampling. Questionnaires were distributed with the aid of a dairy company in Bavaria and the State Inspection Association in Schleswig-Holstein. Of the 800 questionnaires sent out, 151 were returned completed, accounting for a response rate of almost 20%. Our sample size is comparable with that of Birol et al. (2006) who interviewed approximately 100 farmers in 3 different regions of Hungary. From each choice set (as shown in Table 1), respondents were asked to choose the most preferred option: either one of the scheme alternatives or the status quo (no adoption). The “opt-out” alternative had to be included because participation in GM-free production schemes is voluntary.

The choice sets were compiled by means of SPSS (SPSS Inc., Chicago, IL), which generated 15 sets of all 108 combinations satisfying a balanced orthogonal and fractional factorial design. The D-efficiency value is 94.9, which is sufficiently close to the maximum value of 100 for a perfectly orthogonal and perfectly balanced design (Kuhfeld et al., 1994). In the survey, each farmer was confronted with 7 or 8 randomly chosen choice sets

(Table 1). This was done by splitting the 15 choice sets generated by SPSS into 2 blocks of 7 and 8 choice sets, respectively. A total of 987 choice sets were included in the estimation. Each choice set contained 2 GM-free schemes; hence, $n = 1,974$ scheme alternatives were presented in total.

The Choice Model

The discrete choice method is based on the characteristics theory of value (Lancaster, 1966) and the random utility theory provided by Thurstone (1927) and further extended by McFadden (1974) from paired to multiple comparisons. The theory assumes that nonobservable variables affect individuals' choices and that utility must be seen as a latent construct with an unexplainable component (McFadden, 1974; Manski, 1977). In this context, Lancaster stated that utility will be obtained from the attributes of a good rather than from the good itself.

In our model we consider farmers to be utility-maximizing individuals who choose the alternative with the highest utility. A farmer will therefore only participate in the scheme when the expected utility is higher than the utility obtained from current production.

The utility function can be seen as a vector of attributes associated with each choice alternative and a vector of individual farm and farmer characteristics (Ben-Akiva and Lerman, 2000).

Following the random utility approach, the utility function can be decomposed into 2 parts: (1) a non-stochastic component, which maps the deterministic part of utility dependent on observable attributes of the choice alternative and farm or farmer characteristics; and (2) a stochastic component, which reflects the unobserved random variables with zero mean. The deterministic portion of the function is an additive function (i.e., the sum of influences of the attributes and characteristics). In the estimation, the ordinal attribute variables were dummy-type coded and the status quo option was omitted as base level.

The econometric model aims to estimate the probability of a farmer choosing a specific alternative. The function to be estimated is a logistic function ranging from 0 to 1, depending on the matrix of scheme at-

Table 1. Example of a choice set

Attribute	Scheme 1	Scheme 2	Status quo (opt out)
Feed procurement	Farmer self-procurement	List of suppliers	Conditions remain unchanged.
Monitoring	Audit by dairy company	External audit	
Technical support	Free one-off advice by the dairy company	Advice plus	
Premium (€cent/kg)	2.0	0.5	
I choose:	☐	☐	☐

tributes and the vector of individual farm and farmer characteristics. The effects of scheme attributes and farm/farmer characteristics on choice probabilities are derived from the estimated parameters of the function. For the estimations, it is assumed that the error components are independently and identically distributed following a type 1 extreme value distribution. This condition implies that the variances of the error component of the utilities are identical and the alternatives are independent (Louviere et al., 2000).

After confirming that the independence of irrelevant alternatives assumption holds applying a Hausman test, an alternative-specific-conditional logit model also known as McFadden's conditional logit was employed (McFadden, 1974). The model was estimated using the *asclogit* routine in STATA 12. Based on the estimation results, marginal effects on the likelihood of adoption were computed and used to calculate willingness to accept (**WTA**). The WTA estimates reflect the price premium requested to compensate farmers for the loss of utility from implementing the production requirements. The marginal effects can be interpreted as the change of the outcome variable (here the likelihood of choice) due to an infinitesimal change of independent variables. For discrete variables it is not appropriate to calculate the marginal effect in terms of infinitesimal changes. Thus, as a preliminary step, the marginal effects were calculated at the sample mean and subsequently a discrete change (from 0 to 1) of the variable of interest was simulated that leads to a change in the corresponding probability. The difference of both probabilities represents the average marginal effect of the dummy variable or categorical variable (Breustedt et al., 2008). By setting the marginal effect of an explanatory variable in relation to the marginal effect of the price premium, the WTA for that variable is denoted in monetary terms.

To capture the heterogeneity of preferences, interaction terms between scheme attributes and farm/farmer characteristics were included in the model. As explained in Materials and Methods, the value placed on the attributes is strongly related to individual resource settings and current production practices. For example, support to procure GM-free feed may be valued differently by different farmers depending on whether they are already feeding non-GM protein components. Additionally, provision of advice might be more important to farmers who have previously accepted advice on other matters and are more receptive toward agricultural advice in general. Thus, the first and the second interaction terms are products of the attributes "DAIRY_PROC" and "LIST" with the variable "SEG," a variable indicating the use of soy extraction grist in the current feeding regimen. The third

and fourth interaction term were created as product of the attributes "DAIRY_ADV" and "PLUS_ADV" and the variable "ADV," which indicates farmers receiving technical assistance in other fields.

In addition to the mixed logit model, a latent class model (**LCM**) was estimated allowing parameter estimates to vary among distinguishable latent classes where the preferences are homogeneous within but differ substantially across the classes. In contrast to the mixed logit model, the distribution of coefficients is discrete, with the parameter estimates taking distinct values (Train, 2003). To assess farmers' willingness to adopt GM-free production, investigation of preferences among different groups and hence application of an LCM is most suitable (Birol et al., 2011). Farmers are assigned to latent groups according to their individual characteristics, attitudes and the farm properties. The LC analysis is based on the STATA estimation command *lclogit* by Pacifico and Yoo (2012).

RESULTS

Descriptive Statistics

Table 2 presents the descriptive statistics of the whole sample ($n = 151$). The average age of respondents was 44 yr; 87% were farm managers (owner operators) and thus the decision-makers on the farm. Over half of the respondents had vocational qualifications or a college or university degree (High Edu) and 90% of all farmers achieved their qualification in the field of agriculture. The majority of farms are pure agricultural enterprises. A few of the farms also have photovoltaic systems. The share of feeding soy extraction grist (**SEG**) within the sample is considerable (almost 80%). The attitudinal variables indicate that, on average, respondents believe that GM soy cultivation has a negative effect on biodiversity. Respondents' assessment of consumer demand for GM-free milk is rather neutral on average. Concerning feed prices for conventional soy and oilseed rape, they expect, on average, rather unstable and increasing prices in the future.

Notable differences were found between the 2 study regions (Table 3). Average farm size and the share of permanent grassland were twice as high in Schleswig-Holstein as in Bavaria. The same holds for herd size. The share of land used for arable forage production is slightly higher in Schleswig-Holstein. The share of farmers feeding SEG and buying fodder mixture is also higher in Schleswig-Holstein, indicating a stronger reliance on the animal feed market.

Only minor differences regarding the attitudinal variables were found between the samples. Respondents' attitude toward GMO is on average rather negative,

Table 2. Summary statistics of respondents (n = 151)

Item ¹	Mean (SD)	Explanation
Variable, mean (SD)		
Age	44.2 (8.6)	Age of participant (yr)
Farm Acr	100.39 (65.8)	Farm acreage (total in hectares)
Grassland	43.8 (28.2)	Grassland (total in hectares)
Forage Prod (n = 57)	17.44 (20.59)	Forage production (total in hectares of arable land)
Corn Sil (n = 127)	30.05 (40.84)	Production of corn for silage (total in hectares)
Herd size	86 (65)	Herd size (number of cows)
Milk yield	7,188.8 (1,431.3)	Milk yield in kilograms per cow and year
Income milk	66.65 (21.17)	Share of farm income from milk production
Dummy variable (1 = yes), proportion of affirmative response (%)		
Farm manager	86.99	Respondent is farm manager
Young	14.21	Farm manager is under 35 yr
Successor	46.58	Farmer has a successor
High Edu	52.05	Farmer with vocational training, degree from a technical college, or university degree
ADV	68.75	Farm uses advisory services
Agri-branch	44.52	Farm is solely an agricultural enterprise
SEG	79.45	Farmer is feeding soy extraction grist (SEG)
Conc_Purch	58.90	100% of concentrates purchased
Categorical variable, mean (SD)		
Negative effect of GMO	2.5 (0.98)	Item: "The cultivation of GM-soy has a negative impact on biodiversity in the producing countries." (1 = I fully agree; 5 = I fully disagree)
Assessment of consumers' WTP	3.02 (1.03)	Item: "Consumers have a higher willingness to pay for GM-free milk." (1 = I fully agree; 5 = I fully disagree)
GM-free milk = short lived trend	2.92 (0.97)	Item: "GM-free milk is a short-lived trend." (1 = I fully agree; 5 = I fully disagree)
Feed price volatility	3.7 (0.94)	Expectation of volatility of feed prices (soy and oilseed rape) compared with the current year (1 = prices will be very stable; 5 = prices will be very unstable)
Feed price development	3.91 (0.97)	Expectation of long-term (10 yr) feed price development (soy and oilseed rape; 1 = prices will be decreasing; 5 = prices will be increasing)

¹GMO = genetically modified organism; WTP = willingness to pay.

and farmers from both regions expect increasing and more volatile prices of conventional soy and oilseed rape in the future. Farmers have rather neutral views on consumers' willingness-to-pay for GM-free milk and the statement that GM-free milk is a short-lived trend.

Estimation Results

We begin by presenting the results of the conditional logit model. First, the estimation was conducted for the whole sample, then for subsets by region. Subsequently, marginal effects on the likelihood of adoption and also the respective compensation payment (WTA) in eurocents per kilogram of milk were calculated for each explanatory variable. Table 4 reports the estimation results for the whole sample. Tables 5 and 6 show the marginal effects and compensation prices for the whole sample and differentiated by region, respectively. The full model includes all exogenous variables. To improve model fit, only variables significant at the 10% level or below were included in the estimation of a parsimonious model (see right-hand column of Table 4). Following a likelihood ratio test (χ^2 -value = 4.37; Prob > χ^2 =

0.9292), 8 insignificant variables were omitted from the model without impairing the model fit. Additionally, a robust Wald test (χ^2 value = 2.65 with α = 0.9151) confirmed the hypothesis that the coefficients of the omitted variables are zero. The McFadden pseudo R^2 of the parsimonious model is 0.208, which indicates an extremely good model fit according to Louviere et al. (2000).

From the 987 decisions, 53.2% were in favor of conversion to GM-free milk production. Out of all 151 farmers, 35 (23.2%) always chose the GM-free scheme. By contrast, 34 respondents (22.5%) never chose a scheme option. From the farmers who always chose the scheme, 23 are located in Schleswig-Holstein and 12 in Bavaria. From those who have never accepted a scheme, 24 are located in Schleswig-Holstein and 10 in Bavaria. The overall probability that a GM-free alternative is accepted is 0.48 (Bavarian farmers, 0.47; farmers from Schleswig-Holstein, 0.48). On average, respondents requested a mark-up of 0.80 eurocents per kilogram of milk to accept a contract.

Among the scheme attribute variables, the price premium has the greatest influence on adoption. The

Table 3. Descriptive statistics of respondents by region

Item ¹	Bavaria (n = 57)	Schleswig-Holstein (n = 94)
Variable, mean (SD)		
Age	45.4 (8.48)	43.48 (10.0)
Farm Acr	58.23 (28.05)	124.81 (69.07)
Grassland	24.57 (12.66; n = 51)	56.21 (27.86; n = 89)
Forage Prod	4.55 (6.17; n = 19)	23.89 (22.25; n = 38)
Corn Sil	10.9 (6.58; n = 48)	35.79 (46.13; n = 79)
Herd size	37.4 (23.8)	68.7 (56.7)
Milk yield	6,240.539 (1,186.306)	7,726.26 (1,274.60)
Income milk	63.33 (17.72)	68.48 (22.74)
Dummy variables (1 = yes), proportion of affirmative response (%)		
Farm manager	89.09	85.71
Young	11.61	15.71
Successor	47.27	46.15
High Edu	47.14	54.94
ADV	66.03	70.32
Agri-branch	39.53	61.22
SEG	67.27	86.81
Conc_Purch	10.90	87.91
Negative effect of GMO	2.34 (1.00)	2.59 (0.96)
Estimation of consumers' WTP	2.75 (1.00)	3.17 (1.02)
GM-free milk = short lived trend	3.13 (0.99)	2.8 (0.95)
Feed price volatility	3.72 (0.91)	3.75 (0.95)
Feed price development	4.01 (0.91)	3.85 (0.99)

¹GMO = genetically modified organism; WTP = willingness to pay.

Table 4. Estimation results of the conditional logit model (full sample estimation)¹

		Full model	Parsimonious model
Log-likelihood		−831.796, coefficient (SD)	−836.557, coefficient (SD)
Production scheme attributes x	PREMIUM	1.165*** (0.120)	1.176*** (0.112)
	SELF_PROC	−0.125 (0.499)	—
	DAIRY_PROC	−0.908* (0.571)	−0.846*** (0.136)
	LIST	−0.018 (0.528)	—
	DOCU	−0.036 (0.141)	—
	EXT_AUD	−0.548* (0.164)	−0.496*** (0.135)
	DAIRY_CONT	0.242† (0.192)	0.249* (0.148)
	NO_ADV	−1.432* (0.676)	−1.337*** (0.336)
	DAIRY_ADV	−1.565* (0.703)	−1.494*** (0.370)
	PLUS_ADV	−1.590* (0.717)	−1.525*** (0.363)
Interaction terms	DAIRY_ADV* ADV	0.451* (0.260)	0.488* (0.254)
	PLUS_ADV* ADV	0.466* (0.253)	0.499* (0.248)
	DAIRY_PROC*SEG	−0.042 (0.343)	—
	LIST*SEG	0.005 (0.305)	—
Socio-economic variables and farm characteristics z	Young	−0.559* (0.205)	−0.544* (0.200)
	High Edu	−0.574*** (0.156)	−0.545* (0.155)
	Successor	−0.080 (0.157)	—
	Income milk	0.004 (0.004)	—
	Grassland	−0.017*** (0.005)	−0.015* (0.004)
	Region	1.588*** (0.304)	1.533*** (0.288)
	Herd size	0.016* (0.008)	0.007*** (0.002)
	Forage Prod	−0.025*** (0.007)	−0.025*** (0.007)
	Corn Sil	−0.008* (0.003)	−0.010* (0.003)
	SEG	−0.777* (0.267)	−0.772* (0.212)
Attitudinal variables z	Conc_Purch	−1.108*** (0.260)	−1.107*** (0.252)
	Negative effect of GMO soy	1.001*** (0.160)	1.013*** (0.150)
	Consumers' WTP is positive	0.628* (0.193)	0.656*** (0.189)
	GM-free milk = short lived trend	−0.005 (0.184)	—
	Expectation of stable prices (soy and rapeseed)	−0.595* (0.227)	−0.569* (0.227)
	Expectation of decreasing prices (soy and rapeseed oil)	−0.663* (0.276)	−0.607* (0.266)

¹GMO = genetically modified organism; WTP = willingness to pay.

*** $P < 0.001$; * $P < 0.05$; † $P < 0.1$.

attributes “DAIRY_PROC,” “EXT_AUD,” and all levels of technical support including “NO_ADV” exert an adverse effect on scheme adoption. Referring to Key (2005), farmers’ preferences for independence from the dairy company may be a plausible explanation for rejecting attributes that would confine autonomy. An audit by an external certifier (EXT_AUD) is often time-consuming and related to high effort on the part of farmers. By contrast, “DAIRY_CONT” has a positive influence on the probability of adoption, indicating that the monitoring of feedstuff (including laboratory testing) by the dairy company is valued by farmers, presumably as a protection against potential losses of

mark-ups. Among the 4 interaction terms, the ones between the advice attributes and farms that have been receiving advice in other fields are significant. The positive coefficient indicates that farmers who have previously accepted agricultural advice in other cases are more inclined to adopt a GM-free contract when free advice is offered.

In addition to the provisions of the production scheme, farm and farmer characteristics have an effect on the likelihood of adoption. Farmers under 35 are less likely to participate. Regarding a longer planning horizon, younger farmers may rather be interested in investing in productivity-enhancing technologies than

Table 5. Marginal effects on the probability of adoption for whole sample (parsimonious estimation)¹

Item	Variable	Marginal effect	WTA (€cent/kg) CI (2.5%; 97.5%)
Production scheme attributes x	PREMIUM (change +1 ct/kg)	0.294***	—
	DAIRY_PROC	−0.203***	0.691 (0.422; 0.959)
	DAIRY_CONT	0.062*	−0.210 (−0.458; −0.038)
	EXT_AUD	−0.123***	0.417 (0.182; 0.653)
	NO_ADV	−0.298***	1.017 (0.524; 1.510)
	DAIRY_ADV	−0.324***	1.105 (0.545; 1.665)
	PLUS_ADV	−0.329***	1.122 (0.573; 1.670)
	DAIRY_ADV x advised farms	0.118*	−0.403 (−0.832; 0.026)
	PLUS_ADV x advised farms	0.121*	−0.412 (−0.830; 0.007)
Socio-economic variables and farm characteristics z	Young	−0.133*	0.453 (0.112; 0.794)
	High Edu	−0.135***	0.461 (0.92; 0.729)
	Grassland	−0.004***	0.013 (0.005; 0.020)
	Region	0.358***	−1.220 (−1.749; −0.691)
	Herd size	0.002***	−0.006 (−0.108; 0.095)
	Forage Prod	−0.006***	0.021 (0.009; 0.032)
	Corn Sil	−0.003*	0.009 (−0.157; 0.174)
	Feeding SEG	−0.189***	0.645 (0.276; 1.013)
	Conc_Purch	−0.270***	0.919 (0.463; 1.375)
Attitudinal variables z	Negative effect of GMO***	0.248***	−0.843 (−1.133; −0.553)
	Expectation of stable prices (soy and oilseed rape)**	−0.147†	0.471 (0.086; 0.851)
	Expectation of decreasing prices (soy and oilseed rape)**	−0.138*	0.500 (0.045; 0.955)
	Consumers’ WTP is positive***	0.162***	−0.553 (−0.882; −0.223)

¹WTA = willingness to accept; GMO = genetically modified organism; WTP = willingness to pay.

*** $P < 0.001$; * $P < 0.05$; † $P < 0.1$.

Table 6. Marginal effects on the probability of adoption by region (parsimonious estimation)¹

Item	Variable	Bavaria (n = 57)		Schleswig-Holstein (n = 94)	
		Marginal effect	WTA (€cent/kg) CI (2.5%; 97.5%)	Marginal effect	WTA (€cent/kg) CI (2.5%; 97.5%)
Production scheme attributes x	PREMIUM	0.459***	—	0.258***	—
	SELF_PROC	−0.381***	0.831 (0.133; 1.795)	0.126*	−0.489 (−0.823; −0.154)
	DAIRY_PROC	−0.472***	1.028 (0.247; 1.810)	—	—
	LIST	−0.392***	0.854 (0.072; 1.636)	0.272***	−1.056 (−1.753; −0.358)
	DOCU	—	—	0.085†	−0.330 (−0.688; 0.028)
	DAIRY_CONT	0.145*	−0.317 (−0.636; 0.002)	0.142*	−0.549 (−0.942; −0.157)
	EXT_AUD	−0.198***	0.431 (0.135; 0.727)	—	—
Socio-economic variables and farm characteristics z	Young	−0.253*	0.550 (−0.020; 1.120)	−0.128*	0.497 (−1.237; 2.231)
	High Edu	−0.500***	1.088 (0.585; 1.592)	−0.105*	0.408 (−1.114; 1.931)
	Grassland	−0.010*	0.022 (0.005; 0.039)	−0.004*	0.014 (−0.021; 0.049)
	Feeding SEG	−0.387***	0.843 (0.368; 1.318)	—	—
	Conc_Purch	—	—	0.424***	1.641 (−0.450; 3.733)
Attitudinal variables z	Negative effect of GMO	0.193***	−0.421 (−0.839; −0.002)	0.229***	−0.886 (−2.344; 0.572)
	Expectation of stable prices	0.362***	−0.788 (−1.345; −0.231)	0.342***	−1.122 (−1.562; −0.683)
	Expectation of decreasing prices	—	—	−0.266*	1.032 (−1.432; 3.496)
	Consumers' WTP is positive	0.412***	−0.898 (−1.286; −0.510)	0.246***	−0.955 (−2.834; 0.924)

¹WTA = willingness to accept; GMO = genetically modified organism; WTP = willingness to pay.

*** $P < 0.001$; * $P < 0.05$; † $P < 0.1$.

niche production. Higher educational achievement (vocational training, degree from technical college or university) lowers the acceptance of GM-free production. In the literature, the effect of education on the adoption of new technologies is often discussed and no scientific agreement has been achieved on the direction of effect (Knowler and Bradshaw, 2007; Prokopy et al., 2008). Genetically modified organism-free milk production can be seen as a management-intensive technology that does not necessarily require higher education or better knowledge. Such a scheme is feasible for less specialized farms (Dorfner and Uhl, 2012).

Region (0 = Bavaria; 1 = Schleswig-Holstein) and herd size have a significant and positive effect on the likelihood of adoption, implying that farmers with larger farms and those in the lowland regions of northern Germany are more inclined to participate. The share of grassland and land used for cultivation of corn silage, the feeding of SEG, and complete purchasing of concentrate lower the probability of adoption. The availability of grassland and land grown with corn is not necessar-

ily related to the diet of dairy cows in that the biomass may be used to feed anaerobic digesters. The negative effects of feeding SEG and the purchase of concentrates are plausible because farms that strongly rely on the feed market are likely to face higher switching costs.

Of the 5 attitudinal variables, 4 have an effect on the probability of adoption. As expected, farmers with a negative attitude toward cultivation of GM soy and those who are convinced of existing consumer demand for GM-free milk are more likely to adopt a GM-free scheme. Expectations of stable and, in the long run, decreasing prices for GM soy and oilseed rape lower the likelihood of scheme adoption.

Table 5 shows the marginal effects of the attributes and the corresponding WTA estimates based on the parsimonious model. An increase in the price premium by 1 eurocent per kilogram of milk raises the likelihood of adoption by 29 percentage points. Surprisingly, farmers do not like the idea of the dairy company organizing the purchasing of GM-free protein feed on their behalf (the “DAIRY_PROC” option lowers the

acceptance probability by 20 percentage points, and a milk price increment of 0.69 eurocents per kilogram is required to offset this effect). The negative marginal effects for the audit options and technical support measures highlight the respondents' refusal of any form of external intervention. Prescribing audits by an external organization requires a price increment of around 0.42 eurocents per kilogram of milk. Free one-off advice from the dairy company during the conversion period ("DAIRY_ADV") requires a mark-up of 1.11 eurocents; more frequent advice ("PLUS_ADV"), which includes technical assistance on feeding regimens and separation of production lines, is even more expensive (1.12 eurocents per kilogram), although the service would be offered for free. However, large differences are present in respondents' receptiveness to technical support: farmers who already take advice assign a positive value to the service. The coefficient of the 2 interaction terms show that for those farmers the mark-up can be lowered by around 0.40 eurocents per kilogram of milk if free advice is provided.

Socioeconomic and farm variables also affect the likelihood of adoption. Younger farmers (below 35) and better educated farmers (with vocational training or degree) request on average higher mark-ups than older and less well-trained colleagues.

A first hint at regional differences is given by the highly significant coefficient of the "region" variable. A discrete change from 0 (Bavaria) to 1 (Schleswig-Holstein) raises the probability of acceptance by 36 percentage points and lowers the mark-up on the milk price by 1.22 eurocents. The marginal effect of "herd size" is positive but quite low, as are the negative effects of the feeding variables "Forage Prod" and "Corn Sil." An increase in herd size by 10 cows would raise the acceptance probability by 2 percentage points. For farmers who find it difficult to convert to GM-free production due to a high share of SEG request an extra 0.65 eurocents per kilogram.

The attitudinal variables have a notable effect on adoption behavior: farmers who are strongly concerned about the effect of GM soy cultivation request 0.84 eurocents less price premium. Farmers who believe that prices of soy and oilseed will rise require 0.47 eurocents more. Likewise, respondents who are critical of the market success of GM-free milk request a premium of 0.55 eurocents.

To account for regional effects, marginal effects and WTA estimates have been derived for the subsets of farmers in Bavaria and Schleswig-Holstein (Table 6). It is clear from the table that the Bavarian farmers are more responsive to changes in the premium. An increase by 1 eurocent per kilogram milk raises the probability of adoption by 46 percentage points among

the Bavarian respondents and by only 26 percentage points among farmers from Schleswig-Holstein. Marked differences also exist with respect to feed procurement. Farmer self-procurement has a negative effect on adoption and leads to a higher compensation requirement (+0.83 eurocents) in the Bavarian sample, whereas the option is valued positively by Schleswig-Holstein farmers (mark-up lowered by 0.49 eurocents). An opposing effect was also found for the provision of a list of suppliers for GM-free feed. This type of support decreases the likelihood of acceptance in the Bavarian sample but increases it in the sample from Schleswig-Holstein. If the dairy company demands external audits by a certifier agency, this must be "bought" at a price of 0.43 eurocents from the Bavarian farmers, whereas the variable is not significant in the Schleswig-Holstein sample. Feed monitoring offered by the dairy company is valued positively in both samples, lowering the necessary mark-up by 0.32 eurocents in the Bavarian sample and by 0.55 eurocents among farmers from Northern Germany.

Regional differences are also detected for the effects of socio-economic variables. Better educated farmers from Bavaria require a price increment of 1.09 eurocents compared with only 0.41 eurocents for farmers from Schleswig-Holstein. A high share of SEG in the ration is only significant in the Bavarian sample.

The attitudinal variables have the same sign in both samples. The magnitude of the effects is also similar except for farmers' expectations of decreasing prices for GM soy and oilseed rape, which lower the adoption probability in Schleswig-Holstein but are not significant in Bavaria. Farmers who are critical of GM soy cultivation request less compensation. In the Bavarian sample, the required premium is about 2 times lower than that for Schleswig-Holstein.

Latent Class Estimation

To account for heterogeneous preferences among respondents we estimated a latent class model (LCM) which allows parameter estimates to vary among different classes of respondents (Train, 2003). The LCM assumes a finite number of latent structures underlying the data and classifies the sample into groups taking the estimated class membership for each farmer into account. The optimal number of classes is determined ex ante, based on goodness of fit measures (Train, 2008). For the model with 7 attributes and 11 membership variables, 2 classes revealed the best data fit. Table 7 presents the results.

The average membership probability of class 1 is 43.8% and that of class 2 is 56.2%. The average probability of accepting the GM-free production scheme for

Table 7. Results from the latent class estimation¹

Variable	WTA (€cent/kg) CI (2.5%; 97.5%)	
	Class 1	Class 2
DAIRY_PROC	0.444† (−0.074; 0.961)	0.778*** (0.450; 1.107)
DAIRY_CONTR	−0.336† (−0.815; 0.144)	−0.273† (−0.618; 0.073)
EXT_AUD	0.181 (0.771; 0.802)	0.537*** (0.264; 0.809)
NO_ADV	2.709*** (2.221; 3.196)	0.136 (−0.371; 0.643)
DAIRY_ADV	2.749*** (2.178; 3.321)	0.793 (0.414; 1.173)
PLUS_ADV	2.969*** (2.270; 3.668)	−0.021† (−0.486; 0.444)

¹WTA = willingness to accept. Average membership probability: class 1 nonadopters, 43.8%; class 2 adopters, 56.2%.

*** $P < 0.001$; † $P < 0.1$.

farmers in class 2 is 43% and in class 1 only 4.9%. We thus term class 2 members “adopters” and members of class 1 “nonadopters.” As can be seen from the WTA estimates, the nonadopters request prohibitively high compensation for accepting technical assistance in the form of advice. The corresponding variables for the adopters are not significant, except for the “ADV_PLUS” variable, indicating that those who, in principle, are willing to convert are also receptive to accept technical assistance. As one would expect from the estimation results in Table 6, farmers from Bavaria are more likely to be members of the class of nonadopters. Moreover, farmers with a less negative attitude toward cultivation of GM soy and those who are less convinced of existing consumer demand are more likely to be in the class of nonadopters. A comparison of the latent class estimation results and the calculated WTA from the conditional logit models reveals similarities, which is evidence for the robustness of results.

DISCUSSION

This paper set out to investigate farmers’ willingness to accept a GM-free milk production scheme. Similar schemes are being launched by several German dairy companies in response to increasing consumer demand for milk produced without GM feeds. A DCE was carried out to explore dairy farmers’ likely responses to alternative contractual requirements and incentives. The empirical analysis covered the 2 main milk production regions of Germany: Bavaria in the south and Schleswig-Holstein in the north.

Our findings are largely consistent with those of Schulz (2013) who investigated dairy farmers’ acceptance of contract requirements including a ban on GM

feed. They calculated a compensation price of 0.77 eurocents for banning GM feed from dairy cow rations. Our analysis yielded an estimate of 0.80 eurocents on average. Our estimates of the necessary mark-up for farms feeding soy extraction grist also accord with those of Schulz (2013): 0.65 eurocents in our study and 0.65 eurocents in the Schulz study.

The findings of the present study reveal a potential willingness to adopt GM-free milk production among dairy farmers. This is slightly higher in the northern part of Germany with its favorable farm structures and natural circumstances. The latent class estimations, however, revealed large differences in farmers’ preferences. Just over half of the respondents were classified as potential adopters, willing to consider trade-offs between stricter production requirements and higher price premiums. The remaining 44% appear to be resistant to the range of incentives offered in the experiment.

Besides the price premium on offer, monitoring of feed samples and free advice are positively valued by potential adopters. Offering reliable feedstuff monitoring to ensure that the feed is actually free from GMO is thus likely to be an effective means for dairy companies of enticing farmers into GM-free production schemes. Also, dairy companies are well advised to target farmers who have been receiving technical advice in other fields: such farmers are more receptive to scheme-specific technical assistance and, as a consequence, request lower price premiums when free technical advice is offered. However, any interference with the entrepreneurial autonomy of the farmer, be it through prearranged feed procurement or prescriptive advice on the part of the dairy company, lowers the acceptance of the scheme—a finding in agreement with Key (2005) who stresses farmers’ preference for autonomy.

Although no obvious conclusions can be drawn from the variables representing current feeding regimens, the estimation results confirm that farmers who are more reliant on external feeds are less likely to adopt GM-free production. This study has also highlighted the role of soft factors: farmers’ attitudes toward GM soy cultivation, their assessment of consumer demand for GM-free milk, and expectations of future concentrate feed prices all have a strong effect on adoption. Dairy companies wishing to launch GM-free production schemes should thus focus on intensive communication of their marketing strategy as a means of encouraging farmer collaboration. Comparison of the estimates for the 2 regions suggests that dairy farmers in northern Germany are, on average, more likely to convert to GM-free production; however, farmers in Bavaria are *ceteris paribus* more responsive to an increase in the price premium offered. With the exception of feed monitoring, all other attributes of technical support lowered

adoption probabilities, indicating a strong preference for monetary incentives among respondents.

Although this paper offers first insights into likely responses of dairy farmers to alternative production requirements and financial incentives, more research is needed to derive more comprehensive conclusions. Nonmonetary motives and socio-economic factors such as communication and interaction among farmers in social networks are likely to affect adoption behavior as shown by Läpple and Kelley (2014) for the adoption of organic farming. We leave this for future research.

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